

*Made to measure*

# OPERATING INSTRUCTIONS AND SYSTEM DESCRIPTION FOR THE

## EXT-02F

# EXTRACELLULAR AMPLIFIER WITH FILTERS

One or Two Channel Recordings



VERSION 4.2

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## 1. Safety Regulations

**VERY IMPORTANT:** Instruments and components supplied by npí electronic are **NOT** intended for clinical use or medical purposes (e.g. for diagnosis or treatment of humans), or for any other life-supporting system. npí electronic disclaims any warranties for such purpose. Equipment supplied by npí electronic must be operated only by selected, trained and adequately instructed personnel. For details please consult the **GENERAL TERMS OF DELIVERY AND CONDITIONS OF BUSINESS** of npí electronic, D-71732 Tamm, Germany.

- 1) **GENERAL:** This system is designed for use in scientific laboratories and must be operated by trained staff only. General safety regulations for operating electrical devices should be followed.
- 2) **AC MAINS CONNECTION:** While working with the npí systems, always adhere to the appropriate safety measures for handling electronic devices. Before using any device please read manuals and instructions carefully.  
The device is to be operated only at 115/230 Volt 60/50 Hz AC. Please check for appropriate line voltage before connecting any system to mains.  
Always use a three-wire line cord and a mains power-plug with a protection contact connected to ground (protective earth).  
Before opening the cabinet, unplug the instrument.  
Unplug the instrument when replacing the fuse or changing line voltage. Replace fuse only with an appropriate specified type.
- 3) **STATIC ELECTRICITY:** Electronic equipment is sensitive to static discharges. Some devices such as sensor inputs are equipped with very sensitive FET amplifiers, which can be damaged by electrostatic charge and must therefore be handled with care. Electrostatic discharge can be avoided by touching a grounded metal surface when changing or adjusting sensors. **Always turn power off when adding or removing modules, connecting or disconnecting sensors, headstages or other components from the instrument or 19" cabinet.**
- 4) **TEMPERATURE DRIFT / WARM-UP TIME:** All analog electronic systems are sensitive to temperature changes. Therefore, all electronic instruments containing analog circuits should be used only in a warmed-up condition (i.e. after internal temperature has reached steady-state values). In most cases a warm-up period of 20-30 minutes is sufficient.
- 5) **HANDLING:** Please protect the device from moisture, heat, radiation and corrosive chemicals.

## 2. EXT-02F

### 2.1. Components

The following items are shipped with the EXT-02F system:

- ✓ Amplifier (EXT-02F/2 or EXT-02F/1)
- ✓ User manual

⇒ **Optional:** Differential headstage(s) with connectors

### 2.2. System Description

The EXT-02F is designed for extracellular recordings of small voltage signals. The standard model (EXT-02F/2) comprises of two identical channels, but a one channel version (EXT-02F/1) is also available. In the following description of the system only one channel is mentioned, because front panel elements of the two recording channels are identical.

The EXT-02F has a differential input with high input impedance to avoid noise. The output voltage signal can be HIGH PASS or LOW PASS filtered, and is available either AC (HIGH PASS filtered) or DC coupled with variable gain.

Two LEDs indicate whether the amplifier is running out of its linear range, and an analog balance monitor makes the control of OFFSETS easy. A built-in audio speaker monitors the output signal of one channel (A or B). A THRESHOLD function (in NOISE mode) can be used for masking the noise of the baseline. A phone jack allows connection of an external speaker (HEAD PHONES) or further audio amplification, e.g. computer sound card, active speakers, power amplifier etc.

### 2.3. Description of the Front Panel

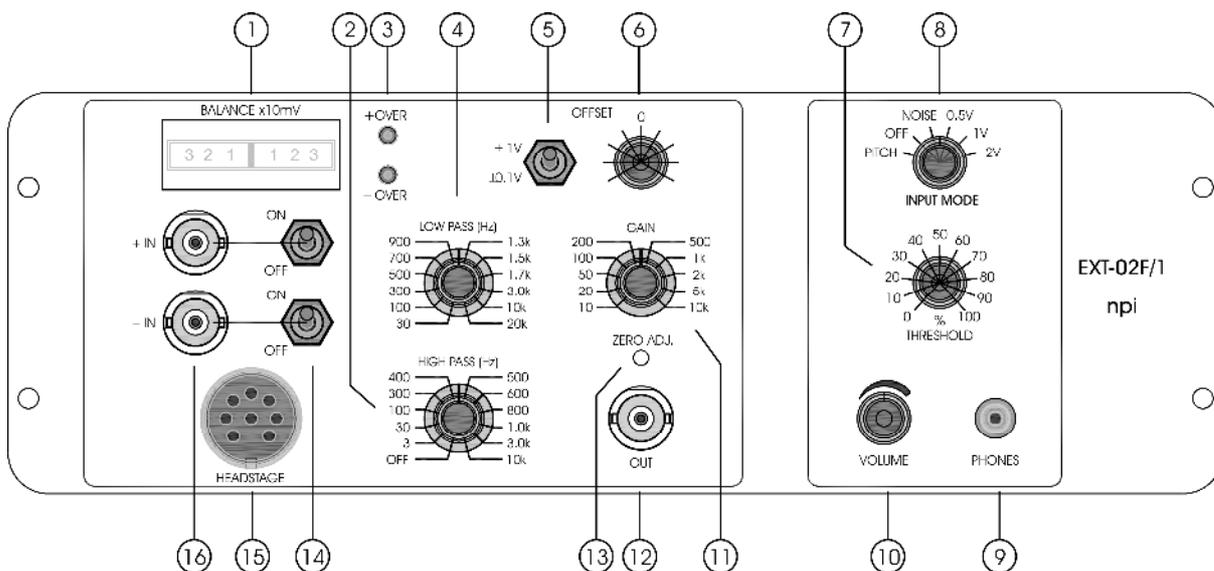


Figure 1: EXT-02F/1 front panel view (one channel version)

In the following description of the front panel elements, each element has a number that is related to that in Figure 1. The number is followed by the name (in uppercase letters) written on the front panel and the type of the element (in lowercase letters). Then, a short description of the element is given. Since the front panel elements for the two channel EXT-02F are identical for each channel A and B (with identical functions and labels) these elements are numbered and described only once (for channel A).

**(1) BALANCE x10mV meter**



Analog BALANCE monitor that displays the OFFSET in the range of  $\pm 30$  mV and is used for optimal cancellation of the OFFSET.

**(2) HIGHPASS (Hz) switch**



12-position switch for selecting the corner frequency of the single pole HIGHPASS filter with -6 dB / octave. In OFF position the HIGHPASS filter is disabled (DC recording).

Corner frequencies (Hz): 3, 30, 100, 300, 400, 500, 600, 800, 1k, 3k, 10k.

**Note:** A combination of both LOWPASS and HIGHPASS FILTER leads to a filter with bandpass characteristics.

**(3) + / - OVERLOAD LEDs**



LEDs that indicate if the amplifier works at 10% below its positive or negative limit. The linear range of the amplifier is  $\pm 12$  V.

**(4) LOWPASS (Hz) switch**



12-position switch for selecting the corner frequency of the single pole LOWPASS filter with -6 dB / octave. Corner frequencies: 30, 100, 300, 500, 700, 900, 1.3k, 1.5k, 1.7k, 3k, 10k, 20k Hz.

**Note:** A combination of both LOWPASS and HIGHPASS FILTER leads to a filter with bandpass characteristics.

**(5) OFFSET range switch**

**(6) Switch to set the range for the OFFSET potentiometer (#6).**

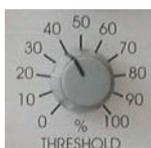


$\pm 1$ V corresponds to a range from -1000 mV to +1000 mV at the electrode  
 $\pm 0.1$ V corresponds to a range from -100 mV to +100 mV at the electrode

**(7) OFFSET potentiometer**

Potentiometer for OFFSET compensation for the measured potential in DC mode. The RANGE is set by switch #5. The analog BALANCE monitor (#1) displays the OFFSET in the range of  $\pm 30$  mV, and can be used for optimal cancellation of the OFFSET.

**Note:** The middle position corresponds to 0 V OFFSET since negative as well as positive OFFSETS can be cancelled.

**Audio Monitor****(8) THRESHOLD % potentiometer**

Potentiometer for setting the THRESHOLD in % of the value set by INPUT MODE switch #8 (0.5 V, 1 V, 2 V). For example, if the INPUT MODE switch #8 is set to 2 V and the THRESHOLD potentiometer is set to 50%, the resulting THRESHOLD for monitoring the OUTPUT signal will be at 1 V, i.e. only signals greater than 1 V will be converted into a sound (NOISE). With an amplification of 10000 this corresponds to a signal of 100  $\mu$ V at the electrode.

**(9) INPUT MODE switch**

Switch for selecting the INPUT MODE.

**PITCH:** The voltage of the INPUT signal is converted into a tone with a frequency equivalent to the amplitude of the INPUT voltage.

**OFF:** The audio monitor is switched OFF

**NOISE:** The voltage of the INPUT signal is high pass filtered, amplified and transduced to a sound.

**2 V, 1 V, 0.5 V:** The audio monitor works in NOISE MODE with THRESHOLD function. 100% THRESHOLD is set to the selected value (2 V, 1 V or 0.5 V) (see also #7).

**(10) PHONES connector**

Stereo jack connector for PHONES or an external amplifier (e.g. active speakers).

**(11) VOLUME potentiometer**

Potentiometer for setting the VOLUME of the internal speaker or PHONES linked to connector #9. Turning clockwise will turn up the sound.

For EXT-02F/2 two channel amplifier only

**SOURCE switch**

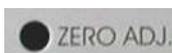
Switch for selecting the channel to be monitored (channel A or channel B)

**(12) GAIN switch**

10-position switch for selecting the GAIN of the output signal at the OUTPUT connector (#12). Amplification factors: x10, x20, x50, x100, x200, x500, x1k, x2k, x5k, x10k.

**(13) OUTPUT connector**

BNC connector providing the recorded and conditioned signal.

**(14) ZERO ADJ. trimpot**

Trimpot for compensating for amplifier offsets. If the baseline is not zero even if the input is grounded (INPUT switches #14 set to OFF), this offset can be compensated for.

**Compensation procedure:**

- Set the input switches (#14) to OFF to ground the inputs, and set the HIGH PASS FILTER to 400 Hz.
- Set the GAIN range switch to 1k and adjust the baseline to zero using the trimpot.
- Set the GAIN range switch to 10k and adjust the baseline again if necessary.

**(14) INPUT switches**

Switches for grounding the INPUT connectors (#16) or the headstage connector (#15). One switch for the + IN and one for the -IN

**Important:** In differential measurements both switches for + IN and - IN have to be set to ON. In single-ended measurements the switch for the INPUT that is not used must be set to OFF!! (see also chapter (3)).

**Also very Important:** Setting both switches to OFF means that both inputs are grounded, i.e. measurement is impossible!! This applies also if a headstage is used since these switches will also ground the headstage inputs REF and P<sub>EL</sub> if set to OFF!!

**(15) HEADSTAGE connector**

Connector for the **optional** headstage (see also chapter (3)).

**(16) -IN, +IN connectors**

BNC connectors for connecting the INPUT signal if no headstage is used, input resistance 1 M $\Omega$ . The inputs can be used in single ended or differential configuration. In differential configuration the signal which is connected to -IN is subtracted from the signal that is connected to +IN. Usually the reference electrode is connected to the -IN connector. If only one INPUT is used (single ended configuration) the other INPUT must be grounded using switch #14 (see also #14 and chapter (3)).

**Very Important:** You **must not** use inputs at the front panel and a headstage for one channel simultaneously!! If the BNC connectors are used the headstage must be disconnected.

**Also very Important:** Setting both switches to OFF means that both inputs are grounded, i.e. measurement is impossible!! This applies also if a headstage is used since these switches will also ground the headstage inputs REF and P<sub>EL</sub> if set to OFF!!

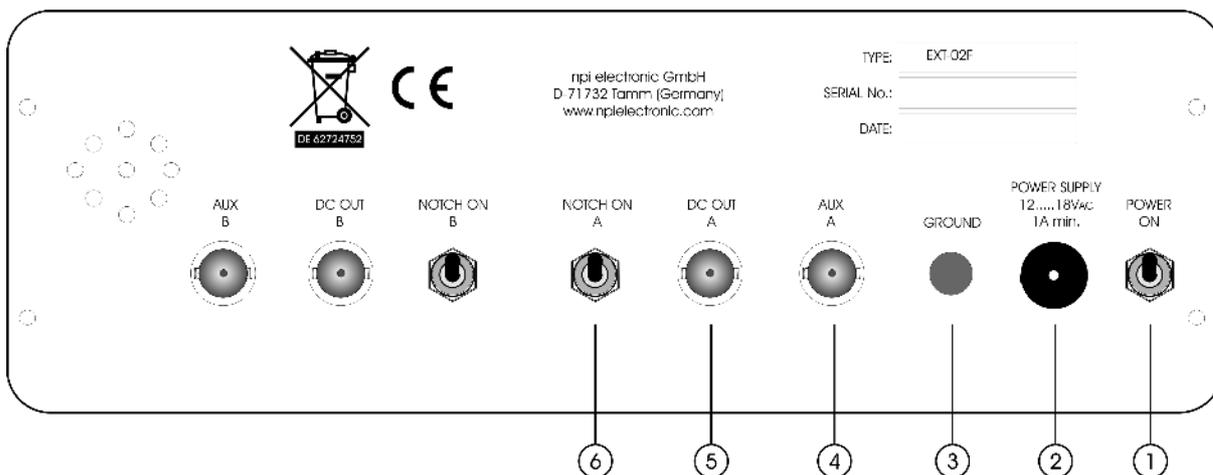
**2.4. Description of the Rear Panel**

Figure 2: EXT-02F rear panel view

Since the rear panel elements for the two channel EXT-02F are identical for each channel A and B (with identical functions and labels) these elements are numbered and described only once (for channel A).

**(1) POWER ON switch**

Switch for turning the EXT amplifier ON (upper position) or OFF (lower position).

**(2) POWER SUPPLY connector**

Connector for an external power supply (12V to 18V, AC, min. 1A).

**Important:** If you encounter noise when operating the EXT-02F try to place the amplifier as far away as possible from the power supply!! This will avoid magnetic coupling of the power supply to the amplifier!

**(3) GROUND connector**

Banana plug providing ground. The plug is connected internally to the shields of the BNC connectors.

**(4) AUX A connector**

BNC connector for a user defined signal. Standard is not connected.

**(5) DC OUT connector**

BNC connector providing the measured DC signal with a fixed amplification of 10. This signal is not filtered. Use of this connector allows, for instance, measuring the signal AC (signal is provided at the front panel) while watching the offset simultaneously.

**(6) NOTCH ON A switch**

Switch that enables (upper position) or disables (lower position) the NOTCH filter (optional).

**2.5. Headstage (Option)**

Figure 3: headstage (optional) and electrode holder (optional) and of the EXT-02F

*Headstage Elements*

- 1 BNC connector for the electrode holder (measuring electrode)
- 2 REF: SMC connector for the reference electrode
- 3 GND: Ground connector
- 4 holding bar

On request, P<sub>EL</sub> can be implemented using 1 mm or 2 mm banana jacks or using SMC connectors.

**Very Important:** EXT-02F headstages are always labeled “EXT-02” (see Figure 3) and must not be exchanged with headstages from other npi electronic EXT amplifiers, e.g. the modular EXT-10 2F or EXT-10C which are labeled “EXT”!

**Also Important:** The shield of the BNC connector of the headstage is connected to driven shield, and must not be connected to ground.

### 3. Operation

The EXT-02F can be operated either using the inputs of the front panel (#16, Figure 1) or using a headstage.

**Very Important:** You **must not** use inputs at the front panel and a headstage for one channel simultaneously!! If the BNC connectors are used the headstage must be disconnected.

**Also Important:** If you encounter noise when operating the EXT-02F try to place the amplifier as far away as possible from the power supply!! This will avoid magnetic coupling of the power supply to the amplifier!

Extracellular measurements are mostly done in slices or *in vivo*, where distortions of the signal caused by other instruments and the animal itself are very common. Additionally, extracellular signals are very small and have to be amplified enormously. The drawback is that noise is amplified as well. Therefore, each channel of the EXT-02F is equipped with differential input that minimizes noise pick-up. Differential means, that the signal for the amplifier is the difference between the positive (+) ( $P_{EL}$  at the headstage) and negative (-) (REF. at the headstage) input of the amplifier. This results in canceling of all signals which both electrodes record, e.g. noise.

For differential measurements, both inputs are connected to electrodes using cables with grounded enclosure or electrode holders. + ( $P_{EL}$ ) is connected to the measuring electrode and - (REF.) to the reference electrode. If no headstage is used, the switches #14, Figure 1 have to be in the same position, i.e. both set to ON. The experimental chamber is grounded by an Ag-AgCl pellet (or an AGAR bridge) connected to GND of the headstage (see Figure 4).

**Important:** If differential measurement is not required (single-ended measurement configuration), the REF input must be connected to ground (GND at the headstage, see Figure 4) or the -IN switch (#14, Figure 1) must be set to OFF.

If no headstage is used, the switch corresponding to the unused INPUT (+ or -) has to be set to OFF (see #14, Figure 1).

The amplifier is in an undefined state, if the REF is left open, and can go into saturation making reliable measurements impossible.

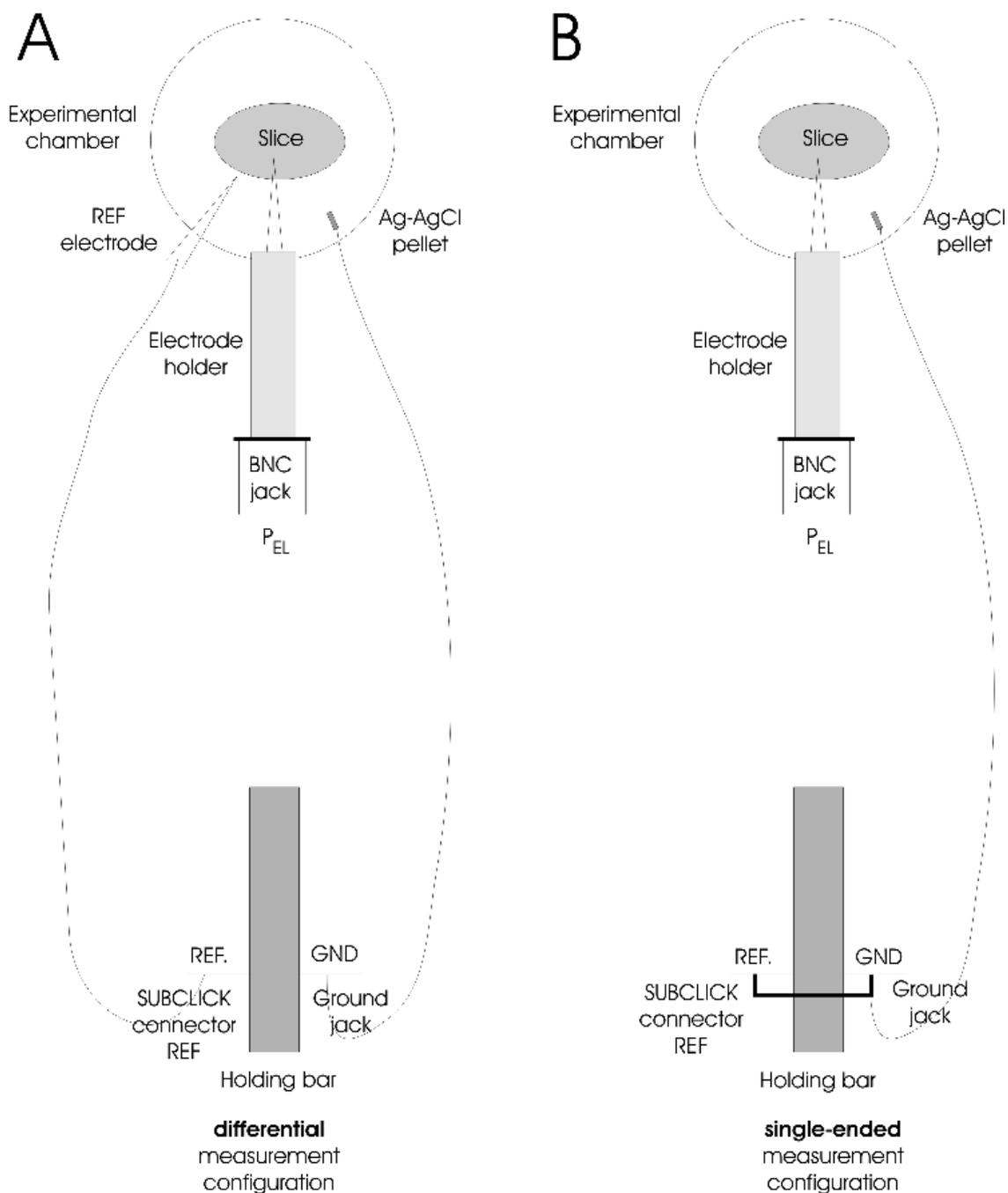


Figure 4: headstage connections, A: differential measurement, B: single-ended measurement

***Hint:*** The REF connector of the headstage can also be set to GND by grounding the  $-IN$  connector at the front panel using #14, Figure 1.

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## 5. Technical Data

Input (BNC connectors):	$10^6 \Omega$ , range $\pm 1 \text{ V}$
Input (headstage):	$>10^{12} \Omega$ , range $\pm 1 \text{ V}$
Differential Input:	CMR $>90 \text{ dB}$ at $1 \text{ kHz}$ (tested with $0 \Omega$ input resistance)
Input Capacitance:	$30 \text{ pF}$
OFFSET compensation:	set by potentiometer, range: $\pm 0.1, \pm 1 \text{ V}$ set by toggle switch
HIGHPASS Filter:	single pole, attenuation: $-6 \text{ dB / octave}$ , corner frequencies (Hz): 3, 30, 100, 300, 400, 500, 600, 800, 1k, 3k, 10k; with OFF position
LOWPASS Filter:	single pole, attenuation: $-6 \text{ dB/octave}$ , corner frequencies (Hz): 30, 100, 300, 500, 700, 900, 1.3k, 1.5k, 1.7k, 3k, 10k, 20k
NOTCH Filter:	Europe: $50 \text{ Hz}$ , USA: $60 \text{ Hz}$
GAIN:	rotary-switch 10-20-50-100-200-500-1k-2k-5k-10k
Overload LEDs:	starting to light up at approx. $\pm 10 \text{ V}$
Output:	range: $\pm 10 \text{ V}$ into $1 \text{ k}\Omega$ / $\pm 1 \text{ V}$ into $50 \Omega$
Potential Monitor:	analog display for the electrode offset, range $\pm 30 \text{ mV}$
Power Supply:	$12\text{V} \dots 18\text{V}$ , AC, min. $1 \text{ A}$
Dimensions:	$245 \times 200 \times 90 \text{ mm}$

### Headstage (optional)

Input (headstage):	$>10^{12} \Omega$ , range $\pm 1 \text{ V}$
Electrode connector:	BNC, shield connected to driven shield
Headstage Size:	$70 \times 26 \times 26 \text{ mm}$
Holding Bar:	length: $150 \text{ mm}$ ; diameter: $8 \text{ mm}$